Claims

1. A method of forming a light emitting diode (LED) comprising:

selecting a first material having properties compatible with fabricating LED layers having desired mechanical characteristics;

providing a first substrate made of the selected first material;

fabricating the LED layers on the first substrate, thereby forming an LED structure;

selecting an optically transparent material compatible with enhancing performance of the LED structure; and

wafer bonding a transparent layer of the selected optically transparent material to the LED layers.

2. The method of claim 1 wherein fabricating the LED layer is a step of epitaxially growing a plurality of layers on the first substrate, the first material being a selection of a material to provide a lattice compatible with epitaxially growing the plurality of layers.

3. The method of claim 1 further comprising removing the first substrate.

4. The method of claim 3 wherein removing the first substrate is a step performed prior to wafer bonding the transparent layer, the wafer bonding being a step of wafer bonding a transparent substrate to a side of the LED structure from which the first substrate is removed.

5. The method of claim 1 wherein wafer bonding the transparent layer to the LED structure is a step performed at elevated temperatures to obtain a low resistance electrical connection, including elevating the temperature to provide softening of the layers to be wafer bonded.

6. The method of claim 5 wherein wafer bonding is a step including applying pressure to the layers to be wafer bonded to achieve conformity of the layers to be wafer bonded.

7. The method of claim 1 wherein at least one of the steps of fabricating the LED layers and selecting the optically transparent material is a step of selecting one of an In-bearing compound, an Hg-bearing compound, a Cd-bearing compound and a Zn-bearing compound at an interface of the layers to be wafer bonded.

8. A method of forming a light emitting diode (LED) comprising:

providing a temporary growth substrate having a lattice compatible with epitaxially growing LED layers;

epitaxially growing a lamination of LED layers on the growth substrate, the lamination having a first side and having a second side coupled to the growth substrate, the growth substrate thereby forming a growth support surface; and

substituting the temporary support surface with a permanent substrate having at least one of a higher electrical conductivity and an increased optical transparency relative to the growth substrate, the substituting including wafer bonding the permanent substrate to one of the first and second sides of the LED layers, the wafer bonding including elevating the temperature at the interface of the permanent substrate and the LED layers to achieve a low resistance connection therebetween.

9. The method of claim 8 wherein substituting the temporary support surface includes removing the growth substrate following the wafer bonding of the permanent substrate to the first side of the LED layers.

10. The method of claim 8 wherein substituting the temporary support surface includes removing the growth substrate prior to the wafer bonding of the permanent substrate to the second side of the LED layers.

11. The method of claim 8 further comprising wafer bonding a second electrically conductive, optically transparent substrate on the LED layers, the permanent substrate being electrically conductive and optically transparent, thereby sandwiching the LED layers between transparent substrates.

12. The method of claim 8 further comprising flowing a dopant gas during the wafer bonding of the permanent substrate so as to increase carrier concentration at the interface of the wafer bond.

13. The method of claim 8 further comprising applying a cap material to at least one of the permanent substrate and the LED layers to retard oxidation prior to the step of substituting the temporary support surface with the permanent substrate, the method further comprising applying heat to decap the at least one of the permanent substrate and the LED layers for the wafer bonding of the permanent substrate to the LFD layers.

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~~14. A light emitting semiconductor device comprising:~~

~~an arrangement of semiconductor layers for generating light in response to a conduction of current;~~

~~an optically transparent wafer-bond layer coupled to said semiconductor layers, an interface of said wafer-bond layer with the semiconductor layers exhibiting properties characteristic of layers that have undergone wafer bonding; and~~

~~electrode means for applying a current to said arrangement of semiconductor layers.~~

15. The device of claim 14 wherein said semiconductor layers are epitaxial layers and said wafer-bond layer is a semiconductor substrate.

16. The device of claim 14 further comprising a transparent wafer-bond substrate on a side of said semiconductor layers opposite to said wafer-bond layer.

17. The device of claim 14 wherein said semiconductor layers form an LED structure.

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18. The device of claim 14 wherein said wafer-bond layer has a conductive ohmic bond ~~low resistance electrical connection~~ to said semiconductor layers.

19. The device of claim 14 wherein said wafer-bond layer is a transparent substrate having a thickness greater than 8 mil, the transparent substrate being wafer bonded to said semiconductor wafers.

20. The device of claim 14 wherein said semiconductor layers include an active layer having an emission energy, said wafer-bond layer being an electrically conductive substrate having an energy gap greater than said energy emission.

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7 ~~21~~. The device of claim 10 further comprising a second optically transparent wafer-bond layer coupled to said semiconductor layers.

22. A method of forming a light emitting diode (LED) comprising:

providing a first substrate;

epitaxially growing a plurality of layers, including active p-n junction layers for generating light in response to the conduction of current, the layers including at least one aluminum-bearing semiconductor layer; and

wafer bonding an optically transparent passivation layer onto the aluminum-bearing semiconductor layer, thereby retarding the occurrence of hydrolysis within the aluminum-bearing semiconductor layer.

23. The method of claim 22 wherein the wafer bonding is a step performed such that desired ohmic characteristics are exhibited at the interface of the passivation layer and the aluminum-bearing semiconductor layer.

24. A method of forming a light emitting diode (LED) comprising:

providing a temporary growth substrate, including selecting the growth substrate to be compatible with lattice matching for the fabrication of LED layers;

growing the LED layers on the growth substrate, the LED layers having a first side and having a second side joined to the growth substrate; and

wafer bonding an electrically conductive mirror to one of the first and second sides of the LED layers to reflect light emitted in the direction of the mirror, including elevating the temperature of the LED layers and the mirror during the wafer bonding such that a low resistance connection is achieved.

25. The method of claim 24 further comprising removing the growth substrate, the removal of the growth substrate occurring prior to the wafer bonding where the mirror is wafer bonded to the second side of the LED layers.

26. The method of claim 24 wherein the mirror is supported on a second substrate.

27. A method of stacking light emitting diodes (LEDs) comprising:

epitaxially growing first LED layers to form a first LED structure;

epitaxially growing second LED layers to form a second LED structure;

stacking the first LED structure onto the second LED structure; and

wafer bonding the first LED structure to the second LED structure.

28. The method of claim 27 wherein said first LED layers are grown on a temporary growth substrate, the method further comprising removing the temporary growth substrate.

29. The method of claim 27 wherein wafer bonding includes aligning the first and second LED structures such that said first and second LED structures have the same polarity.

30. The method of claim 27 further comprising the tunnel junction between the first and second LED structures, the tunnel junction having a polarity opposite to the first and second LED structures.

31. A method of forming a light emitting diode (LED) having a plurality of layers including adjacent first and second layers joined at an interface, the method comprising the steps of:

patterning a first surface of the first layer such that at least one of the optical and electrical properties will selectively vary along the interface of the first and second layers; and

wafer bonding the first surface of the first layer to the second layer.

32. The method of claim 31 further comprising epitaxially growing LED layers, patterning the first surface of the first layer including selecting a pattern to define a desired electrical current path to the epitaxially grown LED layers.

33. The method of claim 31 wherein patterning the first surface of the first layer includes removing material from the first layer to form a depression along the first surface.

34. The method of claim 33 further comprising forming an electrode aligned with the depression for applying a voltage, the electrode being positioned at a side of the first layer opposite to the second layer.

35. The method of claim 31 wherein the first layer is selected of a material to form a current spreading window layer.

36. The method of claim 31 wherein patterning the first surface includes selecting a pattern to define a light reflection pattern for light generated by the LED.

37. A method of forming a light emitting diode (LED) comprising:

providing a first substrate;

providing a II-VI LED structure on the first substrate; and

wafer bonding one of a III-V semiconductor substrate and a SiC substrate to the II-VI LED structure, thereby enhancing stability of the II-VI LED structure.

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